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A phantom based validation framework for EEG-fMRI acquisition methods

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Purpose / Introduction

Scanner generated artefacts on EEG in combined EEG-fMRI recordings is a major problem. Different acquisition methods and filtering algorithms for reducing artefacts have been developed, but most validations lack the knowledge of the true signal, or are based on simulations with assumptions. To our knowledge, Negishi *et al* performed the most realistic phantom-based validation described in literature [1]. We present an enhanced electronic phantom-based set-up that includes motion sensitivity and avoids perfectly periodic generated signals. Two methods providing EEG free of gradient artefacts in combined EEG-fMRI recordings are compared for demonstration.

Subjects and Methods

The methods chosen for demonstration were 1) the fMRI gradient artefact slice template removal (FASTR) algorithm [2] and 2) artefact avoidance using the Magstripe MRI technique (Magstripe system) [3]. The validation set-up is schematized in figure 1. An artificial EEG voltage signal was generated from a PC with an IO card (Polabs, PoKeys55) outside the scanner room, dampened to μV-range and lead into the scanner room and split. One output was connected to a channel on a conventional EEG-system (Brainproducts GmbH, BrainAmp MR plus). This was considered the true signal used as a reference. The other output was mixed with the signal from electrodes on an EEG-cap, which where short-circuited to form a high-impedance loop. The mixed signal was recorded with the Magstripe system, and with a second channel on the Brainproducts system. The latter was subsequently filtered by the FASTR algorithm. The signals were recorded during MR imaging with an EPI sequence (20 slices, matrix 64x64, TE/TR=41ms/1220ms) and temporally aligned using scanner-generated trigger signals. During the scanning, a test subject was wearing the EEG-cap and made small movements such as deep breaths, coughing and swallowing.

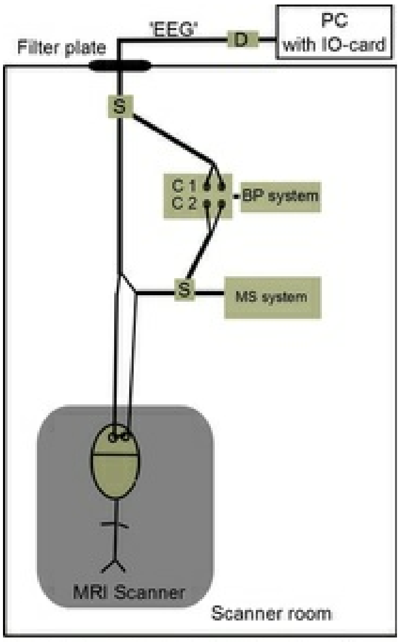

Figure 1: Schematic drawing of the validation set-up. D: Damping circuit; S: Splitter; BP-system: Brainproducts GmbH, BrainAmp MR plus EEG-system; C1: channel 1; C2: channel 2; MS system: Magstripe EEG system.

Results

Figure 2 shows a segment of the resulting signals. High resemblance is seen between the signals exposed to scanner noise and the true signal.

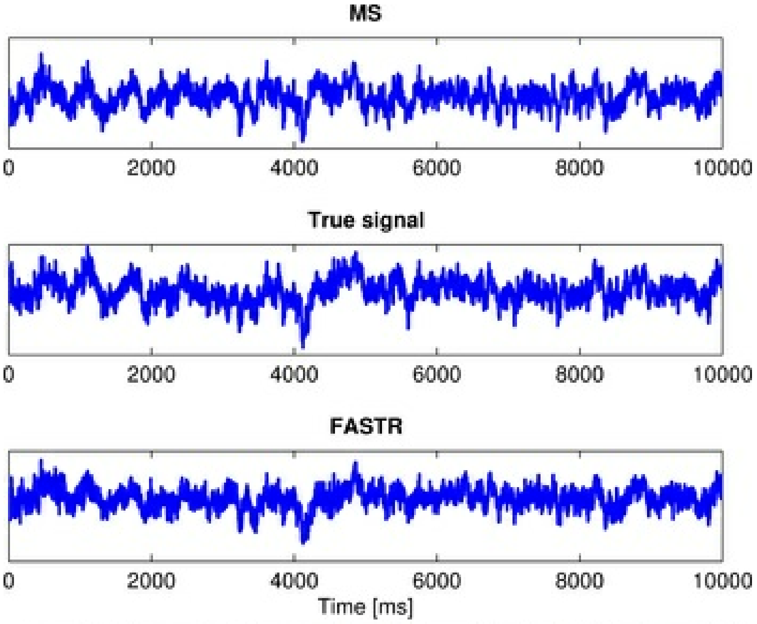

Figure 2: Time series of the recorded and filtered signals. MS: Signal recorded and filtered with the Magstripe system; True signal: EEG signal not exposed to scanner noise; FASTR: The signal exposed to scanner noise after subsequent filtration with the FASTR algorithm.

Discussion/Conclusion

Knowledge of the true signal is the great benefit of electronic phantom-based evaluation methods. Lack of realism can be the drawback. Motion of a subject during scanning is one of the challenges for reducing the scanner induced artefact on the EEG, as motion makes the artefact non-stationary. With the demonstrated set-up, motion aspects can be included in comparisons of methods.

References

[1] Negishi, M. *et al*, 2004, Clin Neurophysiol, 2181-92

[2] Niazy, R. K. *et al*, 2005, NeuroImage, 720-37

[3] Hanson, L. G. *et al*, 2007, J Magn Reson Med, 1059-66

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